CLAIMS

1. A method for modifying a transient audio event in an audio signal, comprising:
detecting a transient audio event in a first portion of the audio signal;
determining a graded response to the detected transient audio event; and
modifying said first portion of the audio signal in accordance with the graded response.

2. The method of claim 1, wherein detecting a transient audio event comprises calculating a spectral flux value associated with said first portion of the audio signal.

3. The method of claim 2, wherein calculating a spectral flux value comprises processing said audio signal using a subband filter bank.

4. The method of claim 3, wherein processing said audio signal using a subband filter bank comprises:
determining the short-time Fourier transform (STFT) for a first frame of the audio signal;
determining the short-time Fourier transform (STFT) for a second frame of the audio signal, wherein the second frame of the audio signal is subsequent in the time domain to the first frame of the audio signal; and
comparing the STFT result for the second frame with the STFT result for the first frame.

5. The method of claim 4, wherein comparing the STFT result for the second frame with the STFT result for the first frame comprises summing the square root of the absolute value of the differences in spectral magnitude between the STFT result for the second frame and the STFT result for the first frame.

6. The method of claim 4, wherein processing said audio signal using a subband filter bank further comprises applying a window to the first frame and the second frame prior to determining the STFT for each respective frame.

7. The method of claim 2, further comprising calculating a normalized spectral flux value associated with the portion of the audio signal.

8. The method of claim 7, wherein calculating a normalized spectral flux value comprises:

calculating a spectral flux value for a frame of the audio signal that is currently being analyzed; and

dividing said spectral flux value for a frame of the audio signal that is currently being analyzed by a normalization factor.

9. The method of claim 8, wherein the normalization factor comprises the maximum spectral flux value determined for any frame of the audio signal.

10. The method of claim 9, wherein the magnitude of the normalization factor is reduced gradually over time to ensure that the normalized spectral flux is not too dependent on the level of the incoming audio signal.

11. The method of claim 1, wherein the audio signal is read from a storage device.

12. The method of claim 1, wherein the audio signal comprises a data stream.

13. The method of claim 12, wherein the data stream is a live data stream received in real time at the time the audio data comprising the audio signal is being generated.

14. The method of claim 1, wherein determining a graded response comprises:

receiving a parameter indicative of the magnitude of the transient audio event; and

providing an indication, based at least in part on the value of said parameter, of the extent to which the first portion of the audio signal should be modified.

15. The method of claim 14, wherein said parameter indicative of the magnitude of the transient audio event comprises a spectral flux value associated with said first portion of the audio signal.

16. The method of claim 14, wherein said parameter indicative of the magnitude of the transient audio event comprises a parameter indicative of the magnitude of the transient audio event relative to transient audio events detected, if any, in other portions of the audio signal.

17. The method of claim 16, wherein said parameter indicative of the magnitude of the transient audio event comprises a normalized spectral flux value.

18. The method of claim 14, wherein said indication comprises a modification factor.

19. The method of claim 18, wherein the modification factor is determined by mapping said parameter indicative of the magnitude of the transient audio event to a corresponding value for the modification factor.

20. The method of claim 19, wherein said mapping comprises using a mapping function of which said parameter indicative of the magnitude of the transient audio event comprises an independent variable and said modification factor comprises a dependent variable.

21. The method of claim 20, wherein said mapping function comprises a linear function.

22. The method of claim 20, wherein said mapping function comprises a nonlinear function.

23. The method of claim 20, wherein said mapping function comprises a hyperbolic tangent function.

24. The method of claim 20, wherein said mapping function comprises a piecewise linear approximation of a nonlinear function.

25. The method of claim 20, wherein said mapping function comprises a table lookup.

26. The method of claim 20, wherein said mapping function comprises a coefficient, the value of which determines at least in part the value of the modification factor corresponding to any given value of said parameter indicative of the magnitude of the transient audio event.

27. The method of claim 26, wherein said coefficient is associated with a maximum possible value for said modification factor.

28. The method of claim 26, wherein said coefficient is associated with a threshold value for said parameter indicative of the magnitude of the transient audio event.

29. The method of claim 26, wherein said coefficient is associated with a rate of change in the value of said modification factor for an associated unit change in the value of said parameter indicative of the magnitude of the transient audio event for at least a portion of said mapping function.

30. The method of claim 26, wherein the value of said coefficient may be varied to control the degree of modification of the audio signal associated with a given value for said parameter indicative of the magnitude of the transient audio event.

31. The method of claim 30, wherein the value of said coefficient is controlled by a user to whom the audio signal is being rendered.

32. The method of claim 1, wherein modifying said first portion of the audio signal in accordance with the graded response comprises increasing the signal level of said first portion of said audio signal to enhance the transient audio event.

33. The method of claim 1, wherein modifying said first portion of the audio signal in accordance with the graded response comprises decreasing the signal level of said first portion of said audio signal to at least partially suppress the transient audio event.

34. The method of claim 1, wherein modifying said first portion of the audio signal in accordance with the graded response comprises multiplying said first portion of the audio signal by a modification factor.

35. The method of claim 1, wherein modifying said first portion of the audio signal in accordance with the graded response comprises nonlinear modification of said first portion of said audio signal.

36. The method of claim 35, wherein said nonlinear modification comprises:

determining the spectral magnitude of said first portion of the audio signal; and

applying a nonlinear modification to said spectral magnitude of said first portion of the audio signal to yield a modified spectral magnitude value.

37. The method of claim 36, wherein applying a nonlinear modification to said spectral magnitude of said first portion of the audio signal comprises raising said spectral magnitude to an exponent equal to a modification factor.

38. The method of claim 36, wherein applying a nonlinear modification to said spectral magnitude of said first portion of the audio signal comprises adding one to said spectral magnitude of said first portion of the audio signal to obtain a first intermediate result, raising said first intermediate result to an exponent equal to a modification factor to obtain a second intermediate result, and then subtracting one from said second intermediate result to obtain said modified spectral magnitude value.

39. The method of claim 36, wherein modifying said first portion of the audio signal in accordance with the graded response further comprises:

dividing said modified spectral magnitude value by the corresponding original, unmodified spectral magnitude value to obtain a modification ratio; and

multiplying a frequency-domain representation of said first portion of said audio signal by said modification ratio to obtain a modified frequency-domain representation of said first portion of said audio signal;

whereby the spectral magnitude of said modified frequency-domain representation of said first portion of said audio signal matches said modified spectral magnitude value.

40. The method of claim 39, wherein detecting a transient audio event comprises processing said audio signal using a subband filter bank and the method further comprises processing said modified frequency-domain representation of said first portion of said audio signal using an inverse of said subband filter bank

41. The method of claim 40, wherein the subband filter bank comprises a short-time Fourier transform filter bank and processing said modified frequency-domain representation of said first portion of said audio signal using an inverse of said subband filter bank comprises performing the inverse short-time Fourier transform (ISTFT) of said modified frequency-domain representation of said first portion of said audio signal to obtain a modified version of said first portion of said audio signal in the time domain.

42. The method of claim 41, further comprising providing said modified version of said first portion of said audio signal in the time domain as output.

43. The method of claim 42, wherein providing said modified version of said first portion of said audio signal in the time domain as output comprises rendering providing said modified version of said first portion of said audio signal in the time domain to a listener.

44. The method of claim 1, wherein determining a graded response to the detected transient audio event comprises determining a first graded response for a first frequency band and modifying said first portion of the audio signal in accordance with the graded response comprises modifying said first portion of the audio signal within said first frequency band in accordance with said first graded response.

45. The method of claim 44, wherein said first frequency band is defined by a first lower frequency limit and a first upper frequency limit.

46. The method of claim 45, wherein said first lower frequency limit may be varied.

47. The method of claim 45, wherein said first upper frequency limit may be varied.

48. The method of claim 45, wherein at least one of said first lower frequency limit and said first upper frequency limit is determined by a user.

49. The method of claim 44, wherein determining a graded response to the detected transient audio event further comprises determining a second graded response for a second frequency band and modifying said first portion of the audio signal in accordance with the graded response comprises modifying said first portion of the audio signal within said second frequency band in accordance with said second graded response.

50. A method for modifying a transient audio event in an audio signal, comprising:

detecting a transient audio event in a first portion of the audio signal; and

applying a nonlinear modification to said first portion of the audio signal.

51. The method of claim 50, wherein detecting a transient audio event comprises calculating a spectral flux value associated with said first portion of the audio signal.

52. The method of claim 51, wherein calculating a spectral flux value comprises processing said audio signal using a subband filter bank.

53. The method of claim 52, wherein processing said audio signal using a subband filter bank comprises:

determining the short-time Fourier transform (STFT) for a first frame of the audio signal;

determining the short-time Fourier transform (STFT) for a second frame of the audio signal, wherein the second frame of the audio signal is subsequent in the time domain to the first frame of the audio signal; and

comparing the STFT result for the second frame with the STFT result for the first frame.

54. The method of claim 50, wherein said step of applying a nonlinear modification comprises:

determining the spectral magnitude of said first portion of the audio signal; and

applying a nonlinear modification to said spectral magnitude of said first portion of the audio signal to yield a modified spectral magnitude value.

55. The method of claim 54, wherein modifying said first portion of the audio signal in accordance with the graded response further comprises:

dividing said modified spectral magnitude value by the corresponding original, unmodified spectral magnitude value to obtain a modification ratio; and

multiplying a frequency-domain representation of said first portion of said audio signal by said modification ratio to obtain a modified frequency-domain representation of said first portion of said audio signal;

whereby the spectral magnitude of said modified frequency-domain representation of said first portion of said audio signal matches said modified spectral magnitude value.

56. The method of claim 55, wherein detecting a transient audio event comprises processing said audio signal using a subband filter bank and the method further comprises processing said modified frequency-domain representation of said first portion of said audio signal using an inverse of said subband filter bank

57. A method for modifying transient audio events in an audio signal, comprising:

receiving a parameter indicative of the degree of spectral change between a first portion of the audio signal and a second portion of the audio signal; and

modifying said second portion of said audio signal by a factor the value of which is determined at least in part by said degree of spectral change between a first portion of the audio signal and a second portion of the audio signal.

58. A system for modifying transient audio events in an audio signal, comprising:

a transient detector configured to detect a transient audio event in a first portion of the audio signal;

a graded response determination module configured to determine a graded response to the detected transient audio event; and

a modification module configured to modify said first portion of the audio signal in accordance with the graded response.

59. A system for modifying a transient audio event in an audio signal, comprising:
a data input line configured to receive said audio signal; and
a processor configured to:
detect a transient audio event in a first portion of the audio signal;
determine a graded response to the detected transient audio event; and
modify said first portion of the audio signal in accordance with the graded response.

60. The system of claim 59, wherein the data input line is configured to receive said audio signal from an external source.

61. The system of claim 59, wherein the data input line is configured to receive said audio signal from a storage device.

62. The system of claim 59, wherein the data input line is configured to receive said audio signal from a device configured to read a physical medium on which data associated with the audio signal has been stored.

63. A computer program product for modifying a transient audio event in an audio signal, the computer program product being embodied in a computer-readable medium and comprising computer instructions for:
detecting a transient audio event in a first portion of the audio signal;
determining a graded response to the detected transient audio event; and
modifying said first portion of the audio signal in accordance with the graded response.